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Simple Two-way Active Measurement Protocol
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Abstract

This document describes a Simple Two-way Active Measurement Protocol which enables the measurement of both one-way and round-trip performance metrics like delay, delay variation, and packet loss.

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[1.](#) Introduction

Development and deployment of Two-Way Active Measurement Protocol (TWAMP) [[RFC5357](#)] and its extensions, e.g., [[RFC6038](#)] that defined Symmetrical Size for TWAMP provided invaluable experience. Several independent implementations of both TWAMP and TWAMP Light exist, have been deployed, and provide important operational performance measurements.

At the same time, there has been noticeable interest in using a more straightforward mechanism for active performance monitoring that can provide deterministic behavior and inherit separation of control (vendor-specific configuration or orchestration) and test functions. Recent work on IP Edge to Customer Equipment using TWAMP Light from Broadband Forum [[BBF.TR-390](#)] demonstrated that interoperability among implementations of TWAMP Light is challenged because the composition

and operation of TWAMP Light were not sufficiently specified in [RFC5357]. According to [RFC8545], TWAMP Light includes sub-set of TWAMP-Test functions to provide comprehensive solution requires support by other applications that provide, for example, control and security.

This document defines an active performance measurement test protocol, Simple Two-way Active Measurement Protocol (STAMP), that enables measurement of both one-way and round-trip performance metrics like delay, delay variation, and packet loss. Some TWAMP extensions, e.g., [RFC7750] are supported by the extensions to STAMP base specification in [I-D.ietf-ippm-stamp-option-tlv].

2. Conventions used in this document

2.1. Terminology

STAMP - Simple Two-way Active Measurement Protocol

NTP - Network Time Protocol

PTP - Precision Time Protocol

HMAC Hashed Message Authentication Code

OWAMP One-Way Active Measurement Protocol

TWAMP Two-Way Active Measurement Protocol

MBZ May be Zero

2.2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. Operation and Management of Performance Measurement Based on STAMP

Figure 1 presents the Simple Two-way Active Measurement Protocol (STAMP) Session-Sender, and Session-Reflector with a measurement session. In this document, a measurement session also referred to as STAMP session, is the bi-directional packet flow between one specific Session-Sender and one particular Session-Reflector for a time duration. The configuration and management of the STAMP Session-Sender, Session-Reflector, and management of the STAMP sessions can

be achieved through various means. Command Line Interface, OSS/BSS (operations support system/business support system as a combination of two systems used to support a range of telecommunication services) using SNMP or controllers in Software-Defined Networking using Netconf/YANG are but a few examples.

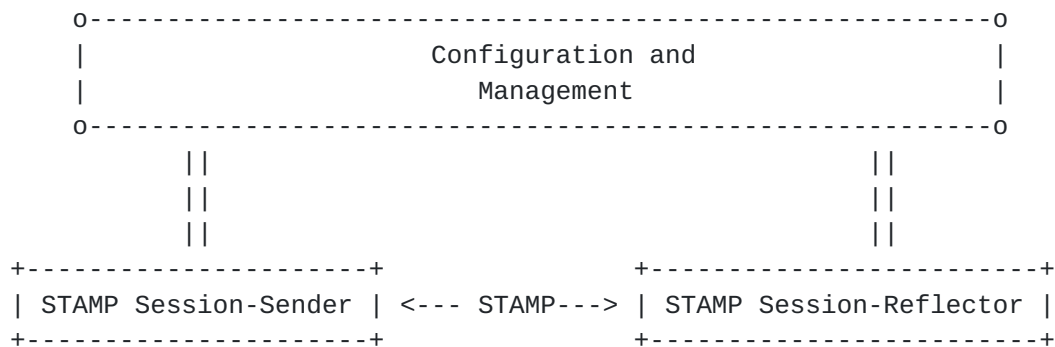


Figure 1: STAMP Reference Model

4. Theory of Operation

STAMP Session-Sender transmits test packets over UDP transport toward STAMP Session-Reflector. A STAMP Session-Sender MUST use UDP port 862 (TWAMP-Test Receiver Port) as the default destination UDP port number. A STAMP implementation of Session-Sender MUST be able to use UDP port numbers from User, a.k.a. Registered, Ports and Dynamic, a.k.a. Private or Ephemeral, Ports ranges defined in [RFC6335]. Before using numbers from the User Ports range, the possible impact on the network MUST be carefully studied and agreed by all users of the network domain where the test has been planned.

STAMP Session-Reflector receives Session-Sender's packet and acts according to the configuration and optional control information communicated in the Session-Sender's test packet. An implementation of STAMP Session-Reflector by default MUST use receive STAMP test packets on UDP port 862. An implementation of Session-Reflector that supports this specification MUST be able to define the port number to receive STAMP test packets from User Ports and Dynamic Ports ranges that are defined in [RFC6335]. STAMP defines two different test packet formats, one for packets transmitted by the STAMP-Session-Sender and one for packets transmitted by the STAMP-Session-Reflector.

STAMP supports two modes: unauthenticated and authenticated. Unauthenticated STAMP test packets, defined in [Section 4.1.1](#) and

[Section 4.2.1](#), ensure interworking between STAMP and TWAMP Light as described in [Section 4.5](#) packet formats.

By default, STAMP uses symmetrical packets, i.e., size of the packet transmitted by Session-Reflector equals the size of the packet received by the Session-Reflector.

[4.1](#). Session-Sender Behavior and Packet Format

STAMP supports symmetrical test packets. The base STAMP Session-Sender packet has a minimum size of 44 octets in unauthenticated mode, see Figure 2, and 112 octets in the authenticated mode, see Figure 4. The variable length of a test packet in STAMP is supported by using Extra Padding TLV defined in [\[I-D.ietf-ippm-stamp-option-tlv\]](#).

[4.1.1](#). Session-Sender Packet Format in Unauthenticated Mode

STAMP Session-Sender packet format in unauthenticated mode:

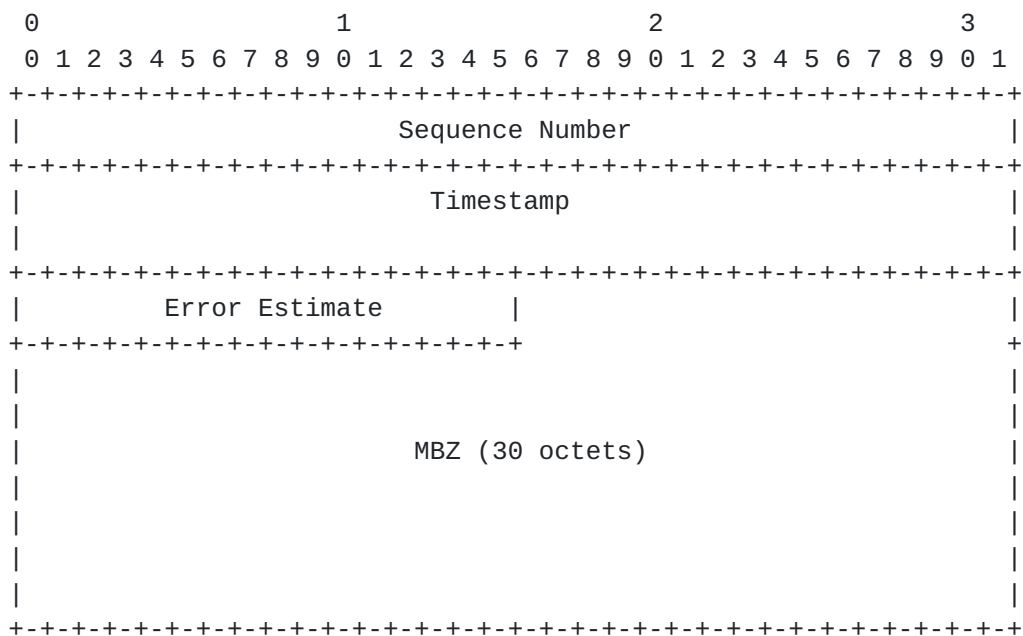


Figure 2: STAMP Session-Sender test packet format in unauthenticated mode

where fields are defined as the following:

- o Sequence Number is four octets long field. For each new session its value starts at zero and is incremented with each transmitted packet.

- o Timestamp is eight octets long field. STAMP node MUST support Network Time Protocol (NTP) version 4 64-bit timestamp format [[RFC5905](#)], the format used in [[RFC5357](#)]. STAMP node MAY support IEEE 1588v2 Precision Time Protocol truncated 64-bit timestamp format [[IEEE.1588.2008](#)], the format used in [[RFC8186](#)].
- o Error Estimate is two octets long field with format displayed in Figure 3

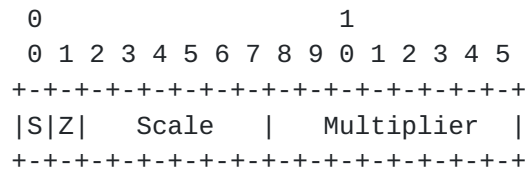


Figure 3: Error Estimate Format

where S, Scale, and Multiplier fields are interpreted as they have been defined in [section 4.1.2 \[RFC4656\]](#); and Z flag - as has been defined in [section 2.3 \[RFC8186\]](#):

- * 0 - NTP 64 bit format of a timestamp;
- * 1 - PTPv2 truncated format of a timestamp.

The STAMP Session-Sender and Session-Reflector MUST use a Z field value of 0, (NTP 64 bit format of a timestamp) as the default. The STAMP Session-Sender and Session-Reflector MAY optionally set the Z field to a value of 1 (PTPv2 truncated format of a timestamp).

- o May-be-Zero (MBZ) field in the session-sender unauthenticated packet is 30 octets long. It MAY be all zeroed on the transmission and MUST be ignored on receipt.

4.1.2. Session-Sender Packet Format in Authenticated Mode

STAMP Session-Sender packet format in authenticated mode:

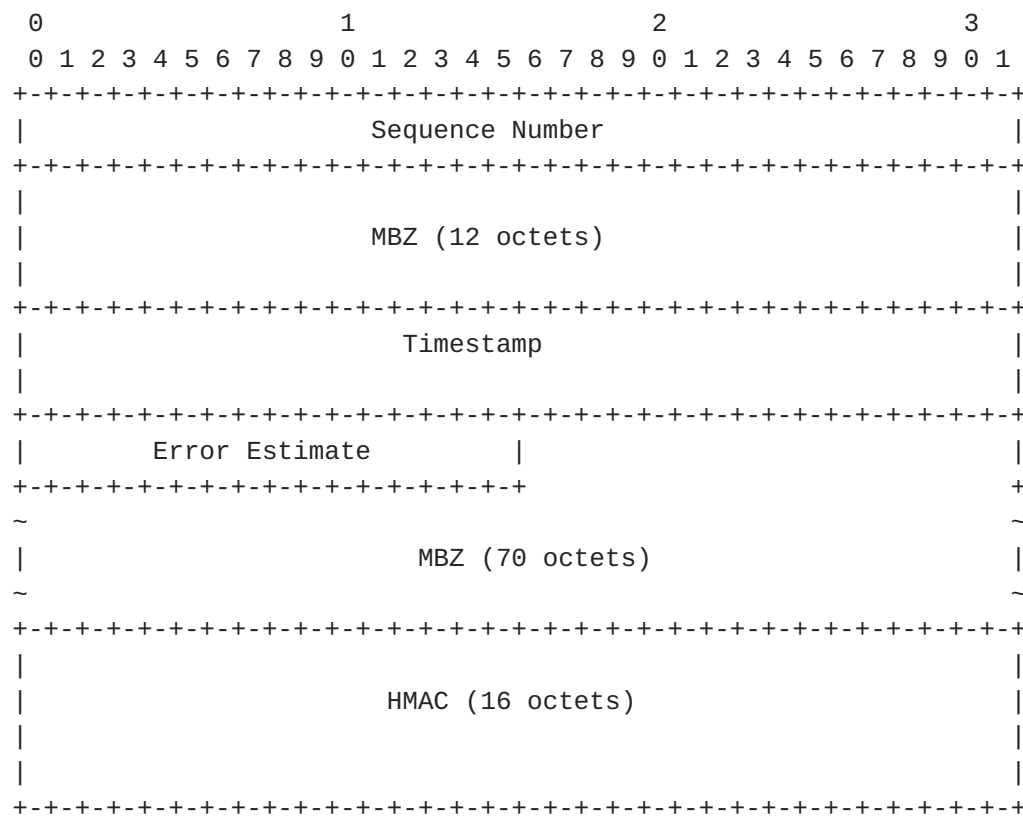


Figure 4: STAMP Session-Sender test packet format in authenticated mode

The field definitions are the same as the unauthenticated mode, listed in [Section 4.1.1](#). Also, MBZ fields are used to align the packet on 16 octets boundary. The value of the field MAY be zeroed on transmission and MUST be ignored on receipt. Also, the packet includes a key-hashed message authentication code (HMAC) ([[RFC2104](#)]) hash at the end of the PDU. The detailed use of the HMAC field is described in [Section 4.3](#).

4.2. Session-Reflector Behavior and Packet Format

The Session-Reflector receives the STAMP test packet, verifies it, prepares and transmits the reflected test packet.

Two modes of STAMP Session-Reflector characterize the expected behavior and, consequently, performance metrics that can be measured:

- o Stateless - STAMP Session-Reflector does not maintain test state and will use the value in the Sequence Number field in the received packet as the value for the Sequence Number field in the reflected packet. As a result, values in Sequence Number and Session-Sender Sequence Number fields are the same, and only

round-trip packet loss can be calculated while the reflector is operating in stateless mode.

- o Stateful - STAMP Session-Reflector maintains test state thus enabling the ability to determine forward loss, gaps recognized in the received sequence number. As a result, both near-end (forward) and far-end (backward) packet loss can be computed. That implies that the STAMP Session-Reflector MUST keep a state for each accepted STAMP-test session, uniquely identifying STAMP-test packets to one such session instance, and enabling adding a sequence number in the test reply that is individually incremented on a per-session basis.

4.2.1. Session-Reflector Packet Format in Unauthenticated Mode

For unauthenticated mode:

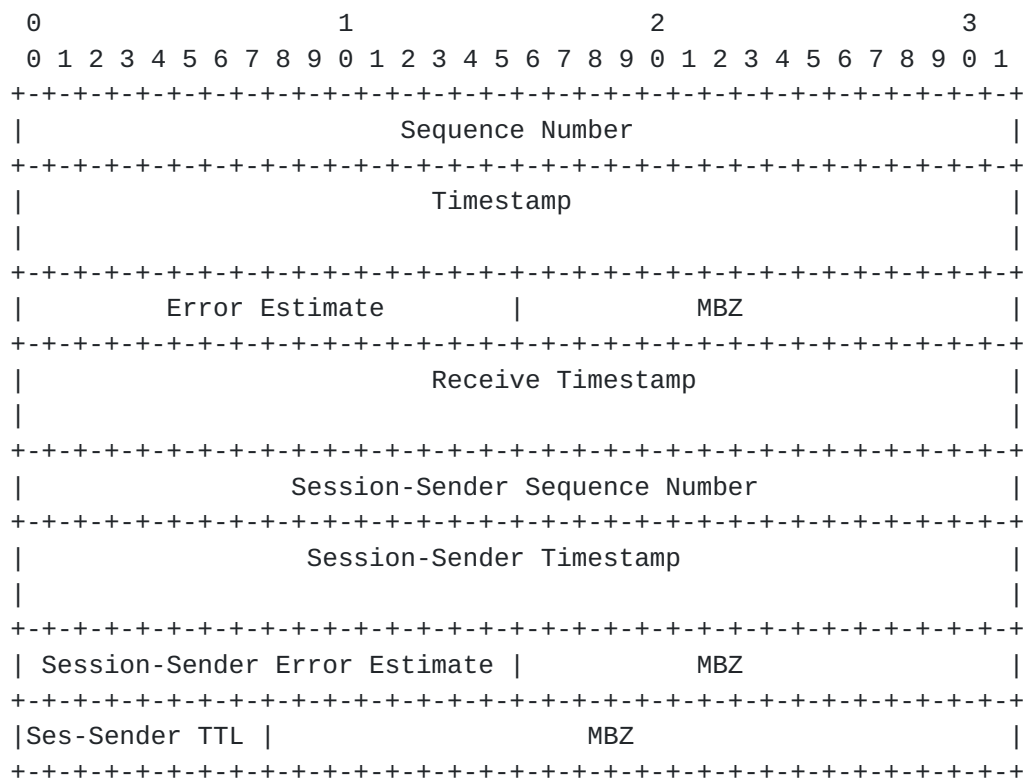


Figure 5: STAMP Session-Reflector test packet format in unauthenticated mode

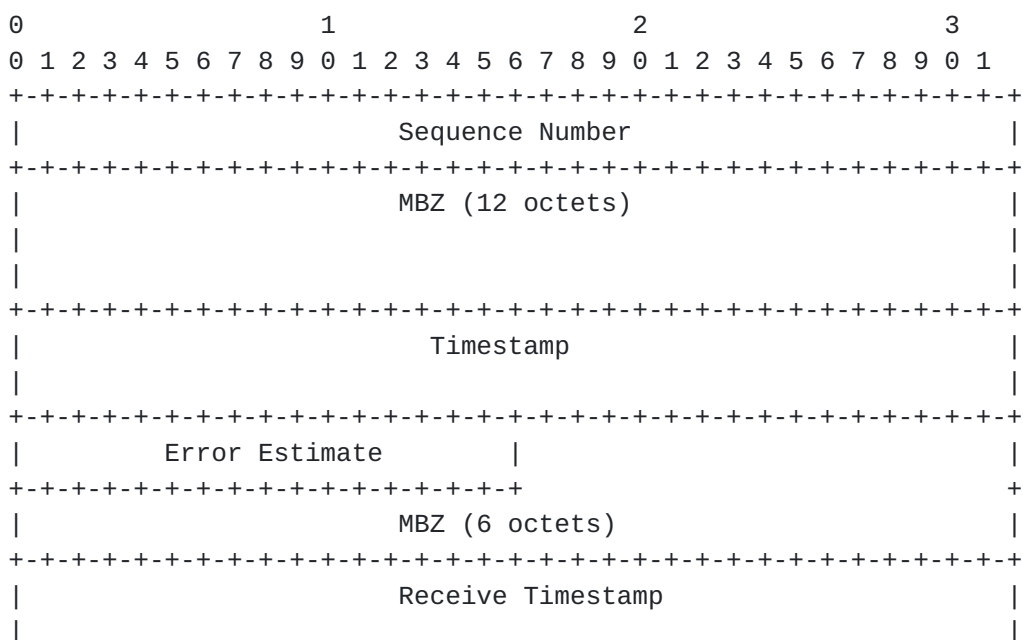
where fields are defined as the following:

- o Sequence Number is four octets long field. The value of the Sequence Number field is set according to the mode of the STAMP Session-Reflector:

- * in the stateless mode the Session-Reflector copies the value from the received STAMP test packet's Sequence Number field;
 - * in the stateful mode the Session-Reflector counts the received STAMP test packets in each test session and uses that counter to set the value of the Sequence Number field.
- o Timestamp and Receiver Timestamp fields are each eight octets long. The format of these fields, NTP or PTPv2, indicated by the Z flag of the Error Estimate field as described in [Section 4.1](#).
- o Error Estimate has the same size and interpretation as described in [Section 4.1](#).
- o Session-Sender Sequence Number, Session-Sender Timestamp, and Session-Sender Error Estimate are copies of the corresponding fields in the STAMP test packet sent by the Session-Sender.
- o Session-Sender TTL is one octet long field, and its value is the copy of the TTL field in IPv4 (or Hop Limit in IPv6) from the received STAMP test packet.
- o MBZ is used to achieve alignment on a four octets boundary. The value of the field MAY be zeroed on transmission and MUST be ignored on receipt.

4.2.2. Session-Reflector Packet Format in Authenticated Mode

For the authenticated mode:



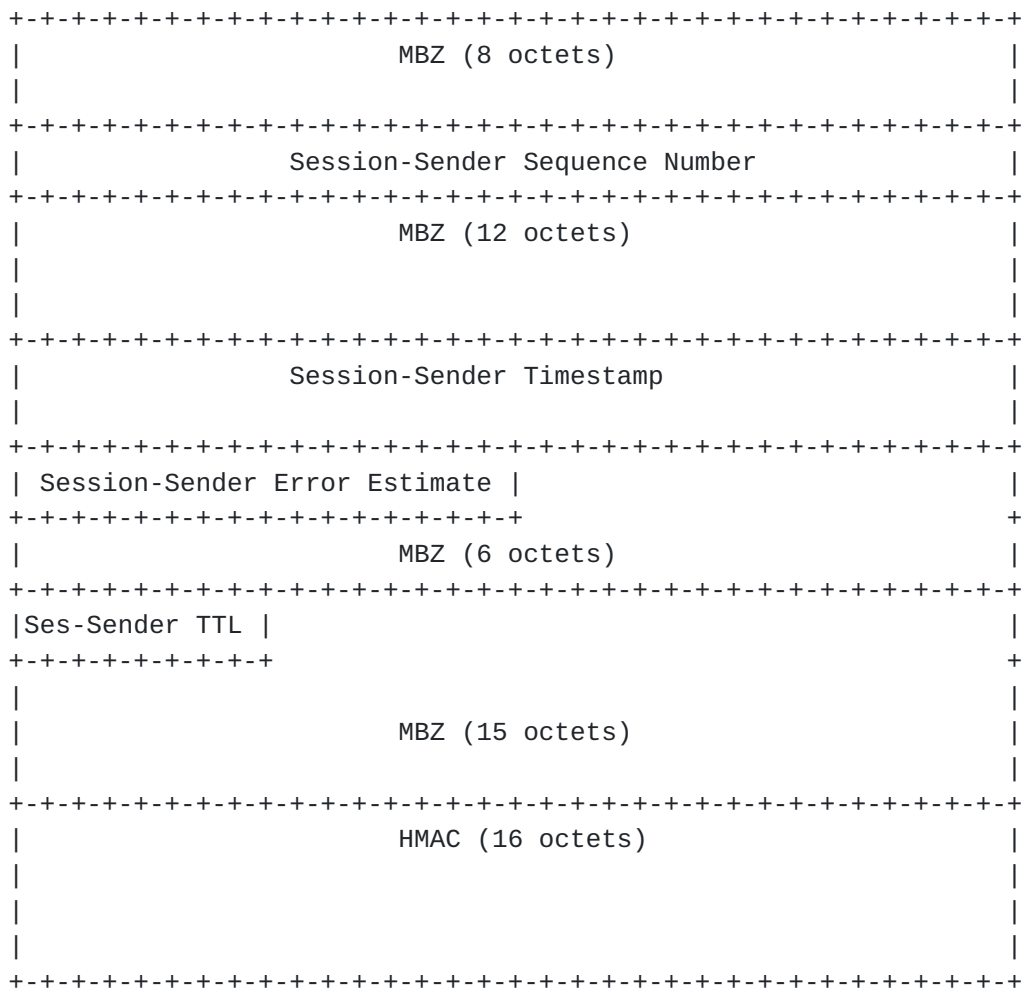


Figure 6: STAMP Session-Reflector test packet format in authenticated mode

The field definitions are the same as the unauthenticated mode, listed in [Section 4.2.1](#). Additionally, the MBZ field is used to align the packet on 16 octets boundary. The value of the field MAY be zeroed on transmission and MUST be ignored on receipt. Also, STAMP Session-Reflector test packet format in authenticated mode includes a key (HMAC) ([[RFC2104](#)]) hash at the end of the PDU. The detailed use of the HMAC field is in [Section 4.3](#).

4.3. Integrity Protection in STAMP

To provide integrity protection, each STAMP message is being authenticated by adding Hashed Message Authentication Code (HMAC). STAMP uses HMAC-SHA-256 truncated to 128 bits (similarly to the use of it in IPsec defined in [[RFC4868](#)]); hence the length of the HMAC field is 16 octets. HMAC uses its own key, and the definition of the

mechanism to distribute the HMAC key is outside the scope of this specification. One example is to use an orchestrator to configure HMAC key based on STAMP YANG data model [[I-D.ietf-ippm-stamp-yang](#)]. HMAC MUST be verified as early as possible to avoid using or propagating corrupted data.

4.4. Confidentiality Protection in STAMP

If confidentiality protection for STAMP is required, a STAMP test session MUST use a secured transport. For example, STAMP packets could be transmitted in the dedicated IPsec tunnel or share the IPsec tunnel with the monitored flow. Also, Datagram Transport Layer Security protocol would provide the desired confidentiality protection.

4.5. Interoperability with TWAMP Light

One of the essential requirements to STAMP is the ability to interwork with a TWAMP Light device. There are two possible combinations for such use case:

- o STAMP Session-Sender with TWAMP Light Session-Reflector;
- o TWAMP Light Session-Sender with STAMP Session-Reflector.

In the former case, the Session-Sender MAY not be aware that its Session-Reflector does not support STAMP. For example, a TWAMP Light Session-Reflector may not support the use of UDP port 862 as defined in [[RFC8545](#)]. Thus STAMP Session-Sender MAY use port numbers as defined in [Section 4](#). If any of STAMP extensions are used, the TWAMP Light Session-Reflector will view them as Packet Padding field.

In the latter scenario, if a TWAMP Light Session-Sender does not support the use of UDP port 862, the test management system MUST set STAMP Session-Reflector to use UDP port number as defined in [Section 4](#). If the TWAMP Light Session-Sender includes Packet Padding field in its transmitted packet, the STAMP Session-Reflector will return the reflected packet of the symmetrical size if the size of the received test packet is larger than the size of the STAMP base packet. The Session-Reflector MUST be set to use the default format for its timestamps, NTP.

STAMP does not support the Reflect Octets capability defined in [[RFC6038](#)]. If the Server Octets field is present in the TWAMP Session-Sender packet, STAMP Session-Reflector will not copy the content starting from the Server Octets field but will transmit the reflected packet of equal size.

5. Operational Considerations

STAMP is intended to be used on production networks to enable the operator to assess service level agreements based on packet delay, delay variation, and loss. When using STAMP over the Internet, especially when STAMP test packets are transmitted with the destination UDP port number from the User Ports range, the possible impact of the STAMP test packets **MUST** be thoroughly analyzed. The use of STAMP for each case **MUST** be agreed by users of nodes hosting the Session-Sender and Session-Reflector before starting the STAMP test session.

Also, the use of the well-known port number as the destination UDP port number in STAMP test packets transmitted by a Session-Sender would not impede the ability to measure performance in an Equal Cost Multipath environment and analysis in [Section 5.3 \[RFC8545\]](#) fully applies to STAMP.

6. IANA Considerations

This document doesn't have any IANA action. This section may be removed before the publication.

7. Security Considerations

[RFC5357] does not identify security considerations specific to TWAMP-Test but refers to security considerations identified for OWAMP in [\[RFC4656\]](#). Since both OWAMP and TWAMP include control plane and data plane components, only security considerations related to OWAMP-Test, discussed in Sections [6.2](#), [6.3](#)[RFC4656] apply to STAMP.

STAMP uses the well-known UDP port number allocated for the OWAMP-Test/TWAMP-Test Receiver port. Thus the security considerations and measures to mitigate the risk of the attack using the registered port number documented in [Section 6 \[RFC8545\]](#) equally apply to STAMP. Because of the control and management of a STAMP test being outside the scope of this specification only the more general requirement is set:

To mitigate the possible attack vector, the control, and management of a STAMP test session **MUST** use the secured transport.

Load of STAMP test packets offered to a network **MUST** be carefully estimated, and the possible impact on the existing services **MUST** be thoroughly analyzed before launching the test session. [\[RFC8085\] section 3.1.5](#) provides guidance on handling network load for UDP-based protocol. While the characteristic of test traffic

depends on the test objective, it is highly recommended to stay in the limits as provided in [RFC8085].

Use of HMAC-SHA-256 in the authenticated mode protects the data integrity of the STAMP test packets.

8. Acknowledgments

Authors express their appreciation to Jose Ignacio Alvarez-Hamelin and Brian Weis for their great insights into the security and identity protection, and the most helpful and practical suggestions. Also, our sincere thanks to David Ball and Rakesh Gandhi for their thorough reviews and helpful comments.

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